# RISK ASSESSMENT FOR DEAD CREEK SECTOR B AND SITES L AND M, SAUGET-CAHOKIA, ILLINOIS

158870

April 28, 1992

Prepared for

Monsanto Company
800 North Lindbergh Boulevard
St. Louis, Missouri

Prepared by

GERAGHTY & MILLER, INC.
Risk Evaluation Group
2840 Plaza Place - Suite 350
Raleigh, North Carolina 27612
(919) 571-1662

**RISK ASSESSMENT FOR**
**DEAD CREEK SECTOR B**
**AND SITES L AND M,**
**SAUGET-CAHOKIA, ILLINOIS**

April 28, 1992

Geraghty & Miller, Inc. is submitting this report to Monsanto Company for a risk assessment of Sector B and Sites L and M of Dead Creek in Sauget-Cahokia, Illinois. The report was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that the report meets the highest standards in terms of the methods used and the information presented. If you have any questions or comments concerning this report, please contact one of the individuals listed below.

Respectfully submitted,

GERAGHTY & MILLER, INC.

for Stanley T. Atwood
Project Toxicologist

Shawn L. Sager, Ph.D.
Principal Scientist

for Dennis Colton
Project Director/Project Officer

## CONTENTS



## TABLES

## TABLES



## FIGURES

# RISK ASSESSMENT FOR DEAD CREEK SECTOR B AND SITES L AND M, SAUGET-CAHOKIA, ILLINOIS

## INTRODUCTION

At the request of the Monsanto Company of St. Louis, Missouri, Geraghty & Miller, Inc. Risk Evaluation Group has prepared a risk assessment for Dead Creek Sector B and Sites L and M, located in Sauget-Cahokia, Illinois (Figure 1). This risk assessment supplements a previous site investigation report prepared by Geraghty & Miller on March 30, 1992 (Geraghty & Miller, Inc., 1992). A description of the site, site history, previous investigations, and field activities was provided in that report and is not repeated here. This risk assessment report is organized into five major sections: Exposure Pathways, Data Summary, Approach and Methods, Risk Characterization, and Finding and Conclusions.

## EXPOSURE PATHWAYS

Dead Creek Sector B and Sites L and M are surrounded by a chain-link fence; thus, access is restricted. Dead Creek Sector B and Site M (a pond) are not used for either fishing or swimming. Site L is covered with cinders and is used as a parking area for heavy machinery. Current on-site exposure to constituents in Dead Creek or Sites L and M is unlikely. The nearest residential communities are located adjacent to Site M along the eastern border and about 1,000 feet east of Site L. Several homes near Site M have private wells which are used for irrigation purposes (Ecology & Environment Inc., 1988). Private wells have not been identified in the small community located east of Site L. Both communities are located hydraulically upgradient from Dead Creek. Any wells in these areas would not be impacted from constituents that could potentially be released from the sites. Thus, no exposure pathways for ground water exist. The only current exposure pathways from the sites include emission of vapors and/or dust to the air and wind transport to the residential communities.

## DATA SUMMARY

Data collected by Geraghty & Miller during the 1991-1992 site investigation were tabulated to represent the occurrence of constituents at various portions of the site (Figure 1). Sediment data were summarized into four groups: Southern section of Dead Creek Sector B, central section of Dead Creek Sector B, Site M, and Site L (Tables 1 through 4, respectively). In addition, one surface-water sample was collected from the southern shoreline of Site M (Table 5). The data summary tables divide the constituents into three groups: volatile organic compounds (VOCs), semi-volatile organic compounds (semi-VOCs), and inorganics. Pesticides were not detected and the analytes requested for each sample point varied within the study area (see Table 2-1 in Geraghty & Miller, Inc. 1992). Other information provided in the data summary tables includes frequency of detection, range of detected concentrations, arithmetic mean concentration, the one-tailed 95 percent upper confidence limit (UCL) of the arithmetic mean, and the exposure point concentration (EPC). The EPC was used to predict air emission rates from the site and is the lesser of the maximum detected concentration or the UCL. Semi-VOCs and inorganics were the most prevalent constituents. More than 30 semi-VOCs were identified and polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were most prevalent. Twenty-two inorganics and eight VOCs were detected. Chlorobenzene was the most prevalent VOC identified.

## APPROACH AND METHODS

Constituents present in sediments and surface water at Dead Creek Sector B and Sites L and M may be released to the air. VOCs present in subsurface soils at Site L may vaporize and migrate into the air. During several months of the year, portions of Dead Creek Sector B are dry. During these months, the potential exists for vapor and fugitive dust emissions from the sediments. Site M contains water throughout the year; therefore, vapor and fugitive dust emissions from this site are unlikely.

All of the organic constituents detected in subsurface soils at Site L and in sediments from Dead Creek Sector B were included in this assessment. Benzoic acid, detected in surface water at Site M, was not included because this constituent will not be expected to vaporize from water. Several constituents were detected in Site M sediments. Exposure to these constituents was not evaluated for several reasons. First, the pond contains water throughout the years precluding fugitive dust emissions. Second, VOCs present in the sediments could vaporize, migrate through the water and reach the air; however, the resulting concentrations were expected to be negligible based on the measured concentrations in sediments and the amount of dilution expected as the constituents move into the water column.

## AIR RELEASE ANALYSIS

The ambient air concentrations of constituents potentially released from Dead Creek Sector B sediments and Site L subsoils as vapors and from Dead Creek sediments as particulates (fugitive dust) were calculated utilizing two approaches. The near-field box model approach (Pasquill, 1975; Horst, 1979) was used to evaluate potential current exposure in the residential area east of Site M. This methodology is applicable to those exposure scenarios where the receptor population is on-site or very close to the site. The near-field box model is appropriate for evaluating air exposures involving short downwind distances (i.e., less than 100 meters). The infinite line source Gaussian dispersion model (Turner, 1970) was used to evaluate potential exposure in the residential community approximately 1,000 feet east of Dead Creek Sector B and Site L. This approach is appropriate for evaluating air exposures at downwind distances greater than 100 meters from long, narrow sources.

The near-field box model is based on the assumption that dispersion in the air does not occur very close to the source. Uniform dispersion of constituents within the box is assumed. The box model is conservative since the concentrations of constituents are assumed to remain constant within the confines of the box. Similarly, wind speed is held constant in the box even though wind speeds actually increase with height from the ground surface. Figure 2 is a diagram of the near-field box model.

The infinite line source Gaussian dispersion model considered Dead Creek Sector B, Site M, and Site L to be a line source and assumed an average rate of emission for vapor-phase and particle-bound constituents. The emission rates, in units of micrograms ($\mu$g) per unit source length (meters) per unit time (seconds), were calculated by summing the absolute emission values ($\mu$g/second) and dividing by the total length of the source (1,320 feet).

## VOLATILE CONSTITUENT EMISSION RATE CALCULATION

The emission rate for each VOC constituent to the atmosphere ($Q_{voc}$) was calculated using the Farmer Model (Farmer et al., 1980), presented as Equation 3 in Table 6. Vapor-phase emissions were calculated for all VOCs and semi-VOCs. The main inputs to this model are the soil-gas diffusion coefficient ($D_g$); the concentration of constituent in soil vapor ($C_g$); and the thickness of clean soil cover (T), which in the absence of site-specific data, is assumed to be 1 centimeter (cm) (the model default value) in the creek bed sediments. The value of T used for Site L subsurface soils was 91 cm (3 feet) because the impacted subsurface soils were found to occur at a depth of 3 feet. To calculate $D_g$ (Equation 2 in Table 6), the site-specific soil parameters total porosity ($P_{tot}$) and air-filled porosity ($P_{air}$) were assumed to be the same, using a default value of 0.5 $cm^3/cm^3$ for sandy-silt soils. $C_g$ was calculated using the method of Hwang and Falco (1986), shown as Equation 1 in Table 6.

The calculated volatile emission rate ($Q_{voc}$) for each VOC was used as an input into the near-field box model and the infinite line source model to calculate their estimated concentrations in ambient air.

## PARTICULATE-BOUND CONSTITUENT EMISSION RATE CALCULATION

Airborne particulates with an aerodynamic diameter of 10 microns or less ($PM_{10}$) are respirable and may be a source of inhalation exposure to particulate-bound constituents (Cowherd et al., 1984). Emission rates for $PM_{10}$ were calculated using the methods described in Cowherd et al. (1984). Table 7 presents the equations used in this analysis.

For this assessment, the sediments in the Sector B creek bed site are assumed to have an "unlimited reservoir" of wind-erodible surface particles. To make a more accurate determination of site soils (unlimited versus limited reservoir), particle-size distribution information is required. Because this information was not available, it was assumed that all the soils were available for wind erosion. The $PM_{10}$ emissions factor, $E_{10}$ is dependent on the threshold wind velocity (Equation 1 in Table 7) and the surface characteristics of the site, as shown in Equation 2 of Table 7.

The constituent-specific emission rates were determined by first calculating the total $PM_{10}$ emission rate (Equation 3 in Table 7), then multiplying the result by the mass fraction of the constituent in soil (using the 95 percent UCL in units of micrograms per microgram [$\mu g/\mu g$]). The resulting particulate emission rate ($Q_{part}$), expressed in micrograms per cubic meter ($\mu g/m3$), was used in the near-field box model to estimate ambient air concentrations of particle-bound constituents.

## ESTIMATED AMBIENT AIR CONCENTRATIONS

The estimated ambient air concentrations ($C_a$) were calculated by solving the equations in Table 8 and were used as EPCs for estimating risks. The proximity of potential receptors to the site and wind speed were considered. Prevailing winds are from the south 7 months, from the northwest 2 months, and from west northwest 3 months of the year at an average speed of 4.2 meters per second (m/s) (Water Information Center, Inc., 1974). However, as a conservative measure, it was assumed that the recptors were always downwind. Air concentrations in the residential community, which is approximately 1,000 feet west of Dead Creek Sector B and Site L, were estimated using the infinite line source Gaussian dispersion model, based on fugitive dust emissions from sediments from the southern and central sections of the creek bed and vapor emissions from subsurface soils at Site L. These concentrations are shown in Table 9. Ambient air concentrations in the residential community directly east of Site M were calculated based on fugitive dust and vapor emissions from the southern section of Dead Creek Sector B and Site M using the near-field box model and are shown in Table 10.

## RISK CHARACTERIZATION

The constituent concentrations in air predicted by the models were used to calculate risk to residents. Two types of risk estimates are provided: (1) the excess lifetime cancer risk (ELCR) for known or suspected human carcinogens and (2) the hazard quotient (HQ) for all constituents.

The ELCR is a probability estimate of the excess lifetime cancer risk (above background incidence) resulting from exposure to constituents released from the site and is based on a unit risk factor. The unit risk factor is the theoretical risk associated with continuous lifetime exposure to a concentration of 1 $\mu g/m^3$. ELCRs are calculated by multiplying the predicted air concentration by the unit risk. Unit risk factors are based on the assumption that any exposure to a carcinogen may cause cancer (non-threshold theory). Regulatory guidance specifies that ELCRs in the range of $10^{-4}$ to $10^{-6}$ are acceptable (U.S. Environmental Protection Agency [USEPA], 1991a). ELCRs are calculated for each constituent and summed to derive the total ELCR.

HQs are the ratio of the predicted air concentration and the reference concentration (RfC) and are not probability estimates. RfCs are defined as the concentration that humans could be exposed to continuously without experiencing any adverse non-cancer effects. However, RfCs are not a strict demarcation between a toxic and non-toxic dose. HQs for each constituent are summed to derive the hazard index (HI). The regulatory guidance specifies that HQs or HIs greater than one are unacceptable.

Unit risks and RfCs (toxicity values) are available from the Integrated Risk Information System (IRIS) (1992) or the Health Effects Assessment Summary Tables (USEPA, 1991b). Toxicity values used in this report are shown in Tables 9 and 10; however, toxicity values were not available for some of the constituents.

Risk estimates for current residents of the community about 1,000 feet east of Site L are shown in Table 9. The ELCR was $3 \times 10^{-10}$, and the HI was 0.000008. Both estimates were well below the regulatory guidance levels and indicate that the site does not pose a threat to residents in this community.

Risk estimates for current residents of the community east of to Site M are shown in Table 10. The ELCR was $4 \times 10^{-9}$, and the HI was 0.00009. These estimates are well below the regulatory guidance levels and indicate that the site does not pose a threat to people currently living next to the site.

The risk estimates provided in this report are conservative, meaning that the actual risks are likely to be much lower. The exposure point concentrations were calculated assuming the receptors were always directly downwind of the site, which is not the case for most of the year. The risk models assumed continuous lifetime exposure to the predicted concentrations and the toxicity values are based on conservative assumptions, which almost certainly result in overestimates of risks. The missing toxicity values were not considered significant in this case because the predicted concentrations were very low and the risk estimates for current exposure were 3 to 5 orders of magnitude lower than the regulatory guidance.

The predicted concentrations at current receptor points were also below current analytical detection limits and below measured ambient concentrations in the United States. For example, PCBs are probably the primary constituent of concern at the site in terms of prevalence, concentration, and toxicity and are ubiquitous environmental contaminants. Typical atmospheric concentrations range from $2 \times 10^{-5}$ $\mu g/m^3$ to $5 \times 10^{-4}$ $\mu g/m^3$ (in remote areas) to $3 \times 10^{-2}$ $\mu g/m^3$ (in urban areas) (Agency for Toxic Substances and Disease Registry [ATSDR], 1991). For comparison, the predicted PCB concentration at the nearest residential community was $1.1 \times 10^{-7}$ $\mu g/m^3$ (Table 10).

## FINDINGS AND CONCLUSIONS

Sediment data collected from Dead Creek Sector B and Sites L and M and surface-water data collected from Site M were evaluated for risks posed to nearby communities. Access to the property is restricted by a chain-link fence and no wells are located downgradient from the site. Air emissions (vapors and particulates) were modeled, and concentrations occurring at the nearest residential communities were predicted. Based on the modeled concentrations, ELCR estimates ranged from $3 \times 10^{-10}$ to $4 \times 10^{-9}$ and were well below the regulatory guidance of $10^{-4}$ to $10^{-6}$. Likewise, the HIs ranged from 0.000008 to 0.00009 and were well below the regulatory guidance of one. Therefore, Dead Creek Sector B and Sites L and M do not pose a health threat to residential communities located near the site.

## REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR), 1991. Update. Draft Toxicological Profile for Selected PCBs (Aroclor -1260, -1254, -1248, -1242, -1232, -1221, and -1016). Public Health Service, U.S. Department of Health and Human Services, Atlanta, Georgia. October, 1991.

Cowherd, C., Jr., G.E. Muleski, P.J. Englehart, and D.A. Gillette, 1984. Rapid Assessment of Exposure to Particulate Emissions from Surface Contamination Sites. Prepared for Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Washington, DC.

Ecology & Environment, Inc., 1988. Expanded Site Investigation, Dead Creek Project Sites at Cahokia/Sauget, Illinois, Final Report. May 1988.

Farmer, W.J., M.S. Young, J. Letey, and W.F. Spencer, 1980. Land Disposal of Hexachlorobenzene Wastes: Controlling Vapor Movement in Soil. Office of Research and Development, Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA 600/2-80-119.

Geraghty & Miller, Inc., 1992. Site Investigation for Dead Creek Sector B and Sites L and M, Sauget-Cahokia, Illinois. March 30, 1992.

Horst, T.W. 1979. Lagrangian Similarity Modeling of Verticle Diffusion from a Ground Level Source.

Hwang, S.T., and J.W. Falco, 1986. Estimation of Multimedia Exposure Related, to Hazardous Waste Facilities. Pollutants in a Multimedia Environment. Y. Cohen, Plenum Press, New York, New York, pp. 229-264.

Integrated Risk Information System (IRIS), 1992. Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt, 1982. Handbook of Chemical Property Estimation Methods. McGraw-Hill, Inc., New York, New York.

Pasquill, F., 1975. The Dispersion of Material in the Atmospheric Boundary Layer--the Basis for Generalization. Lectures on Air Pollution and Environmental Impact Analysis. American Meteorological Society, Boston, Massachusetts.

Turner, D. B., 1970. Workbook of Atmospheric Dispersion Estimates. Office of Air Programs, U.S. Environmental Protection Agency, Research Triangle Park, North Creek.

U.S. Environmental Protection Agency (USEPA), 1991a. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. Office of Solid Waste and Emergency Response, Washington, DC. OSWER Directive 9355,0-30.

U.S. Environmental Protection Agency (USEPA), 1991b. Health Effects Assessment Summary Tables, Annual FY-1991. Office of Solid Waste and Emergency Response, Washington, DC.

Water Information Center, Inc., 1974. Climates of the States, Volume 2. Port Washington, New York.

Table 1. Occurrence of Constituents in Sediment, Dead Creek Sector B, Southern Section, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| VOCs | | | | | |
| Acetone | 1 / 5 | 1.7 - 1.7 | 0.66 | 1.3 | 1.3 |
| Carbon disulfide | 4 / 5 | 0.008 - 0.063 | 0.036 | 0.06 | 0.06 |
| Chlorobenzene | 5 / 5 | 0.44 - 2 | 1.2 | 1.9 | 1.9 |
| Toluene | 2 / 5 | 0.035 - 5.3 | 1.1 | 3.3 | 3.3 |
| Xylenes | 2 / 5 | 0.04 - 0.36 | 0.094 | 0.24 | 0.24 |
| Semi-VOCs | | | | | |
| Acenaphthene* | 3 / 5 | 0.27 - 0.53 | 0.44 | 0.54 | 0.53 |
| Acenaphthylene* | 1 / 5 | 0.96 - 0.96 | 0.58 | 0.92 | 0.92 |
| Anthracene* | 4 / 5 | 0.13 - 1.8 | 0.91 | 1.7 | 1.7 |
| Benzo(a)anthracene** | 5 / 5 | 0.48 - 3.7 | 1.7 | 2.9 | 2.9 |
| Benzo(b)fluoranthene** | 5 / 5 | 1.1 - 30 | 8 | 20 | 20 |
| Benzo(k)fluoranthene** | 5 / 5 | 0.67 - 15 | 4.4 | 10 | 10 |
| Benzo(g,h,i)perylene* | 5 / 5 | 0.38 - 13 | 3.4 | 8.5 | 8.5 |
| Benzo(a)pyrene** | 5 / 5 | 0.55 - 10 | 3.2 | 6.9 | 6.9 |
| bis(2-Ethylhexyl)phthalate | 5 / 5 | 1.2 - 12 | 4.8 | 9.3 | 9.3 |
| 2-Chlorophenol | 3 / 5 | 0.12 - 0.46 | 0.33 | 0.5 | 0.46 |
| Chrysene** | 5 / 5 | 0.84 - 9.4 | 3.1 | 6.5 | 6.5 |
| Dibenzo(a,h)anthracene** | 1 / 5 | 3.9 - 3.9 | 1.8 | 3.6 | 3.6 |
| Dibenzofuran* | 3 / 5 | 0.17 - 1.3 | 0.71 | 1.2 | 1.2 |
| 1,2-Dichlorobenzene | 3 / 5 | 0.96 - 1.7 | 1.2 | 1.7 | 1.7 |
| 1,3-Dichlorobenzene | 4 / 5 | 0.18 - 0.76 | 0.55 | 0.8 | 0.76 |
| 1,4-Dichlorobenzene | 5 / 5 | 1.6 - 2.3 | 1.9 | 2.1 | 2.1 |
| 2,4-Dichlorophenol | 2 / 5 | 0.34 - 0.88 | 0.66 | 0.95 | 0.88 |
| Fluoranthene* | 5 / 5 | 0.84 - 5.4 | 2.4 | 4.3 | 4.3 |
| Fluorene* | 4 / 5 | 0.17 - 1.6 | 0.93 | 1.6 | 1.6 |
| Hexachlorobenzene | 1 / 5 | 0.11 - 0.11 | 0.11 | 0.11 | 0.11 |
| Indeno(1,2,3-c,d)pyrene** | 4 / 5 | 0.27 - 9 | 3.4 | 7.1 | 7.1 |
| 2-Methylnaphthalene* | 3 / 5 | 0.1 - 1.8 | 0.84 | 1.7 | 1.7 |
| Naphthalene* | 4 / 5 | 0.3 - 5.1 | 2.4 | 4.8 | 4.8 |
| N-nitrosodiphenylamine | 1 / 5 | 0.76 - 0.76 | 0.61 | 0.81 | 0.76 |
| Pentachlorophenol | 3 / 5 | 1.5 - 2.9 | 2.4 | 3.1 | 2.9 |
| Phenanthrene* | 5 / 5 | 0.41 - 6.4 | 2 | 4.4 | 4.4 |
| Pyrene* | 5 / 5 | 2.5 - 7.5 | 5.1 | 7.1 | 7.1 |
| PAHs (carcinogenic) | 4 / 5 | 3.91 - 81 | 22 | 54 | 54 |
| PAHs (total) | 5 / 5 | 8.78 - 126.39 | 40 | 87 | 87 |
| PCBs | 10 / 15 | 0.13 - 440 | 84 | 150 | 150 |
| 1,2,4-Trichlorobenzene | 5 / 5 | 1.6 - 4.4 | 3.3 | 4.3 | 4.3 |
| 2,4,5-Trichlorophenol | 1 / 5 | 0.096 - 0.096 | 0.096 | 0.096 | 0.096 |
| 2,4,6-Trichlorophenol | 2 / 5 | 0.35 - 1.4 | 0.98 | 1.5 | 1.4 |

Footnotes appear on page 2.

Table 1. Occurrence of Constituents in Sediment, Dead Creek Sector B, Southern Section, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| Inorganics | | | | | |
| Aluminum | 5 / 5 | 5,780 - 49,200 | 17,000 | 34,000 | 34,000 |
| Antimony | 4 / 5 | 20.3 - 41.9 | 25 | 37 | 37 |
| Arsenic | 5 / 5 | 63.1 - 198 | 110 | 160 | 160 |
| Barium | 5 / 5 | 1,980 - 8,640 | 5,200 | 8,100 | 8,100 |
| Cadmium | 5 / 5 | 22 - 69.6 | 44 | 61 | 61 |
| Calcium | 5 / 5 | 12,500 - 20,400 | 16,000 | 19,000 | 19,000 |
| Chromium | 5 / 5 | 71.1 - 296 | 160 | 240 | 240 |
| Cobalt | 5 / 5 | 10.3 - 17.2 | 13 | 15 | 15 |
| Copper | 5 / 5 | 3,160 - 25,100 | 14,000 | 22,000 | 22,000 |
| Cyanide, total | 3 / 5 | 0.78 - 17.4 | 4.2 | 11 | 11 |
| Iron | 5 / 5 | 24,200 - 48,700 | 37,000 | 48,000 | 48,000 |
| Lead | 5 / 5 | 696 - 2,660 | 1,600 | 2,300 | 2,300 |
| Magnesium | 5 / 5 | 3,030 - 3,660 | 3,300 | 3,600 | 3,600 |
| Manganese | 5 / 5 | 96.4 - 153 | 120 | 140 | 140 |
| Mercury | 5 / 5 | 1.1 - 5 | 2.8 | 4.4 | 4.4 |
| Nickel | 5 / 5 | 292 - 1,260 | 770 | 1,200 | 1,200 |
| Potassium | 5 / 5 | 830 - 2,030 | 1,200 | 1,700 | 1,700 |
| Selenium | 5 / 5 | 4.4 - 9.45 | 6.4 | 8.2 | 8.2 |
| Silver | 5 / 5 | 5.1 - 21 | 14 | 20 | 20 |
| Vanadium | 5 / 5 | 16.4 - 54.8 | 33 | 47 | 47 |
| Zinc | 5 / 5 | 5,140 - 26,100 | 15,000 | 22,000 | 22,000 |

Concentrations are given in milligrams per kilogram (mg/kg).

| | |
|---|---|
| * | Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs). |
| ** | Carcinogenic PAHs (also considered in total PAHs). |
| EPC | Exposure point concentration. |
| Mean | Arithmetic average of the total number of samples. |
| PCBs | Polychlorinated biphenyls. |
| Semi-VOCs | Semivolatile organic compounds. |
| UCL | 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean. |
| VOCs | Volatile organic compounds. |

Table 2. Occurrence of Constituents in Sediment, Dead Creek Sector B, Central Section, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| VOCs | | | | | |
| Acetone | 2 / 5 | 0.24 - 0.29 | 0.18 | 0.26 | 0.26 |
| 2-Butanone | 1 / 5 | 0.2 - 0.2 | 0.089 | 0.16 | 0.16 |
| Carbon disulfide | 5 / 5 | 0.01 - 0.035 | 0.016 | 0.026 | 0.026 |
| Chlorobenzene | 5 / 5 | 0.092 - 13 | 3.1 | 8.4 | 8.4 |
| Ethylbenzene | 3 / 5 | 0.008 - 0.044 | 0.018 | 0.032 | 0.032 |
| Tetrachloroethene | 1 / 5 | 0.03 - 0.03 | 0.017 | 0.027 | 0.027 |
| Toluene | 2 / 5 | 0.025 - 0.069 | 0.025 | 0.049 | 0.049 |
| Xylenes | 1 / 5 | 0.044 - 0.044 | 0.024 | 0.038 | 0.038 |
| Semi-VOCs | | | | | |
| Acenaphthene* | 3 / 5 | 0.098 - 2.6 | 0.79 | 1.8 | 1.8 |
| Anthracene* | 2 / 5 | 1.3 - 2.7 | 1 | 2 | 2 |
| Benzo(a)anthracene** | 4 / 5 | 0.36 - 5.4 | 2.4 | 4.8 | 4.8 |
| Benzo(b)fluoranthene** | 4 / 5 | 0.77 - 6.1 | 2.9 | 5.5 | 5.5 |
| Benzo(k)fluoranthene** | 4 / 5 | 0.78 - 5.2 | 2.5 | 4.8 | 4.8 |
| Benzo(g,h,i)perylene* | 4 / 5 | 0.33 - 3.2 | 1.4 | 2.6 | 2.6 |
| Benzo(a)pyrene** | 5 / 5 | 0.17 - 5.3 | 2.3 | 4.6 | 4.6 |
| bis(2-Ethylhexyl)phthalate | 3 / 5 | 0.086 - 0.91 | 0.53 | 0.85 | 0.85 |
| 2-Chlorophenol | 1 / 5 | 0.11 - 0.11 | 0.11 | 0.11 | 0.11 |
| Chrysene** | 4 / 5 | 0.51 - 7 | 2.8 | 5.6 | 5.6 |
| Dibenzofuran* | 3 / 5 | 0.07 - 2 | 0.62 | 1.4 | 1.4 |
| 1,2-Dichlorobenzene | 2 / 5 | 2.5 - 11 | 3 | 7.3 | 7.3 |
| 1,3-Dichlorobenzene | 3 / 5 | 0.41 - 2 | 0.85 | 1.5 | 1.5 |
| 1,4-Dichlorobenzene | 5 / 5 | 0.11 - 12 | 4 | 8.8 | 8.8 |
| 2,4-Dichlorophenol | 2 / 5 | 0.096 - 0.25 | 0.22 | 0.28 | 0.25 |
| 2,4-Dimethylphenol | 2 / 5 | 0.087 - 0.14 | 0.13 | 0.15 | 0.14 |
| Fluoranthene* | 4 / 5 | 0.43 - 5.2 | 2.3 | 4.6 | 4.6 |
| Fluorene* | 4 / 5 | 0.12 - 4.6 | 1.2 | 3.1 | 3.1 |
| Indeno(1,2,3-c,d)pyrene** | 4 / 5 | 0.46 - 2.8 | 1.3 | 2.3 | 2.3 |
| Isophorone | 1 / 5 | 0.27 - 0.27 | 0.27 | 0.27 | 0.27 |
| 2-Methylnaphthalene* | 3 / 5 | 0.14 - 7 | 1.6 | 4.5 | 4.5 |
| 4-Methylphenol | 1 / 5 | 0.12 - 0.12 | 0.12 | 0.12 | 0.12 |
| Naphthalene* | 4 / 5 | 0.19 - 2.1 | 0.69 | 1.5 | 1.5 |
| Pentachlorophenol | 3 / 5 | 0.32 - 1.6 | 1.1 | 1.8 | 1.6 |
| Phenanthrene* | 4 / 5 | 0.32 - 2.9 | 1.1 | 2.2 | 2.2 |
| Pyrene* | 4 / 5 | 1.2 - 16 | 6.3 | 13 | 13 |
| PAHs (carcinogenic) | 5 / 5 | 0.17 - 30.3 | 14 | 27 | 27 |
| PAHs (total) | 5 / 5 | 0.17 - 67.1 | 28 | 58 | 58 |
| PCBs | 11 / 15 | 0.12 - 301 | 44 | 82 | 82 |
| 1,2,4-Trichlorobenzene | 3 / 5 | 0.38 - 12 | 3.1 | 7.9 | 7.9 |

Footnotes appear on page 2.

Table 2. Occurrence of Constituents in Sediment, Dead Creek Sector B, Central Section, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| Inorganics | | | | | |
| Aluminum | 5 / 5 | 5,640 - 15,400 | 10,000 | 14,000 | 14,000 |
| Antimony | 4 / 5 | 20.7 - 44.5 | 32 | 48 | 45 |
| Arsenic | 5 / 5 | 52.9 - 95.7 | 78 | 95 | 95 |
| Barium | 5 / 5 | 1,890 - 9,510 | 5,300 | 8,800 | 8,800 |
| Cadmium | 5 / 5 | 71.8 - 243 | 120 | 190 | 190 |
| Calcium | 5 / 5 | 7,760 - 23,600 | 13,000 | 19,000 | 19,000 |
| Chromium | 5 / 5 | 63.1 - 125 | 100 | 120 | 120 |
| Cobalt | 5 / 5 | 12.2 - 29.9 | 22 | 29 | 29 |
| Copper | 5 / 5 | 3,560 - 30,100 | 14,000 | 24,000 | 24,000 |
| Cyanide, total | 4 / 5 | 0.53 - 1.5 | 0.77 | 1.2 | 1.2 |
| Iron | 5 / 5 | 31,700 - 86,400 | 54,000 | 75,000 | 75,000 |
| Lead | 5 / 5 | 1,340 - 2,310 | 1,700 | 2,100 | 2,100 |
| Magnesium | 5 / 5 | 2,570 - 4,040 | 3,400 | 4,000 | 4,000 |
| Manganese | 5 / 5 | 128 - 557 | 240 | 410 | 410 |
| Mercury | 5 / 5 | 0.14 - 3.9 | 1.3 | 2.8 | 2.8 |
| Nickel | 5 / 5 | 548 - 2,670 | 1,500 | 2,300 | 2,300 |
| Potassium | 4 / 5 | 796 - 2,420 | 1,400 | 2,200 | 2,200 |
| Selenium | 4 / 5 | 3.7 - 8.7 | 4.7 | 6.9 | 6.9 |
| Silver | 5 / 5 | 4.2 - 50.4 | 19 | 37 | 37 |
| Sodium | 2 / 5 | 215 - 452 | 220 | 350 | 350 |
| Vanadium | 5 / 5 | 44.1 - 58.9 | 52 | 58 | 58 |
| Zinc | 5 / 5 | 4,500 - 42,800 | 20,000 | 36,000 | 36,000 |

Concentrations are given in milligrams per kilogram (mg/kg).

| | |
|---|---|
| * | Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs). |
| ** | Carcinogenic PAHs (also considered in total PAHs). |
| EPC | Exposure point concentration. |
| Mean | Arithmetic average of the total number of samples. |
| PCBs | Polychlorinated biphenyls. |
| Semi-VOCs | Semivolatile organic compounds. |
| UCL | 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean. |
| VOCs | Volatile organic compounds. |

Table 3. Occurrence of Constituents in Sediment, Site M, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| VOCs | | | | | |
| Chlorobenzene | 1 / 2 | 10 - 10 | 5.7 | 33 | 10 |
| Ethylbenzene | 1 / 2 | 0.82 - 0.82 | 0.82 | 0.82 | 0.82 |
| Semi-VOCs | | | | | |
| Acenaphthene* | 1 / 2 | 1.5 - 1.5 | 1.5 | 1.5 | 1.5 |
| Anthracene* | 2 / 2 | 2.5 - 3.9 | 3.2 | 7.6 | 3.9 |
| Benzo(a)anthracene** | 2 / 2 | 9.2 - 9.4 | 9.3 | 9.9 | 9.4 |
| Benzo(b)fluoranthene** | 2 / 2 | 8.4 - 15 | 12 | 33 | 15 |
| Benzo(k)fluoranthene** | 2 / 2 | 6.6 - 9.3 | 8 | 16 | 9.3 |
| Benzo(g,h,i)perylene* | 2 / 2 | 6 - 6 | 6 | 6 | 6 |
| Benzo(a)pyrene** | 2 / 2 | 6.9 - 7.5 | 7.2 | 9.1 | 7.5 |
| bis(2-Ethylhexyl)phthalate | 1 / 2 | 18 - 18 | 13 | 47 | 18 |
| Butylbenzylphthalate | 1 / 2 | 1.6 - 1.6 | 1.6 | 1.6 | 1.6 |
| Chrysene** | 2 / 2 | 9.9 - 12 | 11 | 18 | 12 |
| Dibenzo(a,h)anthracene** | 1 / 2 | 1.2 - 1.2 | 1.2 | 1.2 | 1.2 |
| Dibenzofuran* | 1 / 2 | 2.1 - 2.1 | 2.1 | 2.1 | 2.1 |
| 1,2-Dichlorobenzene | 2 / 2 | 3.3 - 26 | 15 | 86 | 26 |
| 1,3-Dichlorobenzene | 2 / 2 | 2.3 - 4.1 | 3.2 | 8.9 | 4.1 |
| 1,4-Dichlorobenzene | 2 / 2 | 27 - 40 | 34 | 75 | 40 |
| Fluoranthene* | 2 / 2 | 21 - 21 | 21 | 21 | 21 |
| Fluorene* | 2 / 2 | 5.2 - 5.9 | 5.6 | 7.8 | 5.9 |
| Indeno(1,2,3-c,d)pyrene** | 2 / 2 | 3.7 - 4.3 | 4 | 5.9 | 4.3 |
| 2-Methylnaphthalene* | 2 / 2 | 1.6 - 6.9 | 4.3 | 21 | 6.9 |
| Naphthalene* | 2 / 2 | 2.6 - 3.3 | 3 | 5.2 | 3.3 |
| Phenanthrene* | 2 / 2 | 11 - 13 | 12 | 18 | 13 |
| Pyrene* | 2 / 2 | 23 - 27 | 25 | 38 | 27 |
| PAHs (carcinogenic) | 2 / 2 | 45.3 - 58.1 | 52 | 92 | 58 |
| PAHs (total) | 2 / 2 | 129.9 - 137 | 130 | 160 | 140 |
| PCBs | 10 / 10 | 14.9 - 505 | 200 | 290 | 290 |
| 1,2,4-Trichlorobenzene | 2 / 2 | 5 - 14 | 9.5 | 38 | 14 |
| Inorganics | | | | | |
| Aluminum | 3 / 3 | 4,670 - 7,290 | 6,400 | 8,900 | 7,300 |
| Antimony | 2 / 3 | 16.6 - 41.2 | 24 | 49 | 41 |
| Arsenic | 3 / 3 | 7 - 94 | 42 | 120 | 94 |
| Barium | 3 / 3 | 1,760 - 9,060 | 4,600 | 11,000 | 9,100 |
| Cadmium | 3 / 3 | 8.6 - 47.2 | 24 | 58 | 47 |
| Calcium | 3 / 3 | 5,560 - 12,500 | 9,900 | 16,000 | 13,000 |
| Chromium | 3 / 3 | 80 - 183 | 120 | 210 | 180 |
| Cobalt | 3 / 3 | 9.1 - 20.6 | 16 | 27 | 21 |

Footnotes appear on page 2.

Table 3. Occurrence of Constituents in Sediment, Site M, Sauget-Cahokia, Illinois.

| Constituent | Frequency Detects / Total | Range of Detects Min - Max | Mean | UCL | EPC |
|---|---|---|---|---|---|
| Copper | 3 / 3 | 8,150 - 21,000 | 14,000 | 25,000 | 21,000 |
| Cyanide, total | 1 / 1 | 1.3 - 1.3 | 1.3 | NA | NA |
| Iron | 3 / 3 | 16,300 - 48,500 | 28,000 | 58,000 | 49,000 |
| Lead | 3 / 3 | 625 - 1,910 | 1,100 | 2,300 | 1,900 |
| Magnesium | 3 / 3 | 3,090 - 6,200 | 4,500 | 7,200 | 6,200 |
| Manganese | 3 / 3 | 154 - 178 | 160 | 190 | 180 |
| Mercury | 3 / 3 | 0.07 - 0.45 | 0.3 | 0.64 | 0.45 |
| Nickel | 3 / 3 | 959 - 2,490 | 1,600 | 2,900 | 2,500 |
| Potassium | 3 / 3 | 758 - 1,080 | 940 | 1,200 | 1,100 |
| Silver | 3 / 3 | 18 - 26 | 21 | 28 | 26 |
| Sodium | 1 / 3 | 211 - 211 | 180 | 230 | 210 |
| Vanadium | 3 / 3 | 19.3 - 37.7 | 29 | 44 | 38 |
| Zinc | 3 / 3 | 9,930 - 31,600 | 18,000 | 38,000 | 32,000 |

Concentrations are given in milligrams per kilogram (mg/kg).

| | |
|---|---|
| * | Non-carcinogenic polycyclic aromatic hydrocarbons (PAHs). |
| ** | Carcinogenic PAHs (also considered in total PAHs). |
| EPC | Exposure point concentration. |
| Mean | Arithmetic average of the total number of samples. |
| PCBs | Polychlorinated biphenyls. |
| Semi-VOCs | Semivolatile organic compounds. |
| UCL | 95 percent upper confidence limit (one-tailed normal distribution) on the arithmetic mean. |
| VOCs | Volatile organic compounds. |

Table 4. Constituents Detected in Sediment, Site L, Sauget-Cahokia, Illinois.

| Constituent | Sediment Concentration (mg/kg) |
|---|---|
| **VOCs** | |
| Chlorobenzene | 5.3 |
| Toluene | 4.5 |
| Xylenes | 0.54 |
| **Semi-VOCs** | |
| Acenaphthene* | 3.1 |
| Acenaphthylene* | 0.28 |
| Anthracene* | 4.2 |
| Benzo(a)anthracene** | 8.6 |
| Benzo(b)fluoranthene** | 5.4 |
| Benzo(k)fluoranthene** | 4.6 |
| Benzo(g,h,i)perylene* | 3.2 |
| Benzo(a)pyrene** | 5.3 |
| Butylbenzylphthalate | 5.4 |
| Chrysene** | 8.2 |
| Dibenzofuran* | 3.0 |
| Di-n-butylphthalate | 1.8 |
| 1,2-Dichlorobenzene | 7.7 |
| 1,3-Dichlorobenzene | 4.3 |
| 1,4-Dichlorobenze | 100 |
| 2,4-Dichorophenol | 2.4 |
| 4-Chloroaniline | 13 |
| Diethylphthalate | 1.0 |
| Fluoranthene* | 16 |
| Fluorene* | 5.0 |
| Hexachlororbenzene | 4.8 |
| Indeno(1,2,3-c,d)pyrene** | 2.9 |
| 2-Methylnaphthalene* | 2.3 |
| 4-Methylphenol | 3.2 |
| Naphthalene* | 7.3 |
| Pentachlorophenol | 28 |

Footnotes appear on page 2.

Table 4. Constituents Detected in Sediment, Site L, Sauget-Cahokia, Illinois.

| Constituent | Sediment Concentration (mg/kg) |
|---|---|
| Phenanthrene* | 23 |
| Phenol | 13 |
| Pyrene* | 23 |
| PAHs (carcinogenic) | 35 |
| PAHs (total) | 125 |
| PCBs | 500 |
| 1,2,4-Trichlorobenzene | 79 |
| 2,4,6-Trichlorophenol | 1.5 |
| **Inorganics** | |
| Aluminum | 7,320 |
| Arsenic | 49 |
| Barium | 1,440 |
| Cadium | 42 |
| Calcium | 75,500 |
| Chromium | 27 |
| Cobalt | 8.3 |
| Copper | 308 |
| Cyanide | 0.46 |
| Iron | 2,400 |
| Lead | 664 |
| Magnesium | 5,150 |
| Manganese | 535 |
| Mercury | 1.8 |
| Nickel | 95.9 |
| Potassium | 1,130 |
| Vanadium | 27.6 |
| Zinc | 4,240 |

| | |
|---|---|
| * | Non carcinogenic PAHs. |
| ** | Carcinogenic PAHs (also considered in total PAHs). |
| mg/kg | Milligrams per kilogram. |
| PAHs | Polycyclic aromatic hydrocarbons. |
| PCBs | Polychlorinated biphenyls. |
| Semi-VOCs | Semivolatile organic compounds. |
| VOCs | Volatile organic compounds. |

Table 5. Constituents Detected in Surface Water, Site M, Sauget-Cahokia, Illinois.

| Constituent | Surface-Water Concentration ($\mu$g/L) |
|---|---|
| **Semi-VOCs** | |
| Benzoic acid | 3.0 |
| **Inorganics** | |
| Barium | 140 |
| Calcium | 46,000 |
| Copper | 200 |
| Iron | 270 |
| Lead | 11 |
| Magnesium | 3,900 |
| Manganese | 56 |
| Potassium | 3,700 |
| Sodium | 20,000 |
| Zinc | 130 |

$\mu$g/L Micrograms per liter.
Semi-VOCs Semivolatile organic compounds.

Table 6. Equation Definitions for Calculation of Soil/Sediment Vapor Emissions from Dead Creek Sector B and Sites L and M, Sauget-Cahokia, Illinois.

---

The emission rate of each volatile constituent to the atmosphere is calculated by first estimating its concentration in soil gas based on the soil concentration, using the equation presented in Hwang and Falco (1986):

$$C_g = \frac{C_o \times UC_2 \times H}{Kd} \qquad \text{(Eq.1)}$$

where:

- $C_g$ Concentration of constituent in soil vapor below cover ($\mu g/m^3$)
- $UC_2$ Unit conversion 2 (41 mol/atm x $m^3$)
- H Henry's Law Constant (atm x $m^3$/mol).
- Kd Partition coefficient ($cm^3/g$), calculated as the product of Koc ($cm^3/g$), and foc (fraction organic carbon, assumed to be 0.01).

Next, the soil-gas diffusion coefficient, Dg ($cm^2$/sec) is calculated for each constituent:

$$Dg = D_{air} \times (P_{air}^{10/3}/P_{tot}^{2}) \qquad \text{(Eq. 2)}$$

where:

- $D_{air}$ Air-gas diffusion coefficient ($cm^2$/sec) (calculated using methods in Lyman et al., 1982).
- $P_{tot}$ Total soil porosity ($cm^3$ air + liquid/$cm^3$ soil).
- $P_{air}$ Volumetric air content $cm^3$ air/$cm^3$ soil).

The flux of constituent vapor from soil, F ($\mu g$/sec-$cm^2$) is calculated using the Farmer Model (Farmer et al., 1980):

$$F = \frac{Dg \times (C_g - C_o) \times UC_1}{T} \qquad \text{(Eq. 3)}$$

where:

- $C_o$ Concentration of constituent vapor in air at soil surface ($\mu g/m^3$).
- $UC_1$ Unit conversion (1 x $10^{-6}$ $m^3/cm^3$).
- T Thickness of clean soil cover (cm). Assumed to be 1 cm for the creek bed, and 91 cm (3 ft) for Site L.

---

Atm Atmospheres.
cm Centimeter.
$cm^2$ Square centimeters.
$cm^3$ Cubic centimeters.
g Gram.
$\mu$ Micrograms.
$m^3$ Cubic meters.
mol Moles.
sec Second.

Table 6. Equation Definitions for Calculation of Soil Sediment Vapor Emissions from Dead Creek Sector B and Sites L and M, Sauget-Cahokia, Illinois.

---

Finally, the vapor emission rate, $Q_{voc}$ ($\mu$g/sec), is calculated:

$$Q_{voc} = F \times A$$

where:

A Area over which vapor flux occurs ($cm^2$): 2,900,000 $cm^2$ for the central section of Dead Creek, Sector B; 3,300,000 $cm^2$ for the southern section, and 7,600,000 $cm^2$ for Site L.

$Q_{voc}$ also includes a factor normalizing the value to the number of months of the year that the creek bed is dry: 10 months central section; 2 months southern section. Site L was assumed to have emissions all year. Qvoc was then used in the near field box model.

---

| | |
|---|---|
| Atm | Atmospheres. |
| cm | Centimeter. |
| $cm^2$ | Square centimeters. |
| $cm^3$ | Cubic centimeters. |
| g | Gram. |
| $\mu$ | Micrograms. |
| $m^3$ | Cubic meters. |
| mol | Moles. |
| sec | Second. |

Table 7. Equation Definitions for Calculation of Soil/Sediment Particulate Emissions from Dead Creek Sector B, Sauget-Cahokia, Illinois.

---

The emission rate of each semi-VOC and metal constituent to the atmosphere is calculated using the Cowherd $PM_{10}$ emission rate equations. First, the threshold wind speed at a height of 7 m, Ut (m/sec), was calculated.

$$Ut = U(z)/U^* \times (1/0.4) \times \ln (z/z_o) \quad \text{(Eq. 1)}$$

where:

| | |
|---|---|
| U | Wind speed at height z (4.2 m/sec). |
| z | Height above soil surface (7 m). |
| U* | Friction velocity (assumed to be 75 cm/sec based on an "unlimited reservoir" of erodible particles). |
| $z_o$ | Roughness height, assumed to be 1 cm based on site surface characteristic (values suggested by Cowherd et al. (1984). |

Next, the $PM_{10}$ emission factor, $E_{10}$ ($g/m^2$-hr), was calculated using the "unlimited reservoir" model (Cowherd et al., 1984):

$$E_{10} = 0.036 \times (1-V) \times (Um/Ut)^3 \times f(x) \quad \text{(Eq. 2)}$$

where:

| | |
|---|---|
| V | Fraction of total surface area covered by continuous vegetation, assumed to be 0%. |
| Um | Mean annual wind speed (4.2m/sec). |
| f(x) | Value approximated using equation in Appendix B, Cowherd et al., 1984 (0.037, dimensionless). |

Finally, the emission rate of $PM_{10}$, $ER_{10}$ ($\mu g$/sec) was calculated:

$$ER_{10} = ((EF_{10} \times UC_1)/UC_2) \times At \quad \text{(Eq. 3)}$$

where:

| | |
|---|---|
| $UC_1$ | Unit conversion 1 ($1 \times 10^{-6}$ $\mu g/g$). |
| $UC_2$ | Unit conversion 2 (3,600 sec/hr). |
| At | Surface area: 290 $m^2$ for the central portion of Dead Creek, 330 $m^2$ for the southern portion of Dead Creek. |

The constituent-specific emission rate, $Q_{part}$, was then calculated by multiplying the $ER_{10}$ by the mass fraction of the chemical in soil (95% UCL, in $\mu g/\mu g$) and applying a factor normalizing the value to the number of months of the year that the creek bed is dry: 10 months central section; 2 months southern section. The $Q_{part}$ was then used in the near field box model.

---

| | | | |
|---|---|---|---|
| cm | Centimeter. | $\mu g$ | Micrograms. |
| g | Grams. | $PM_{10}$ | Particulate mater < 10 micrometers in diameter. |
| hr | Hour. | sec | Seconds. |
| m | Meter. | semi-VOCs | Semivolatile organic compounds. |
| $m^2$ | Square meter. | UCL | Upper confidence limit. |

Table 8. Equation Definitions for Calculation of Ambient Air Concentrations using the Near-Field Box Model and the Infinite Line Source Model, Dead Creek Sector B and Sites L and M, Sauget-Cahokia, Illinois.

---

The emission rates for vapor-phase and particle-bound constituents to the atmosphere are used in the box model to calculate ambient air concentrations, Cvoc and Cpart ($\mu g/m^3$),in the current residential community located south of Sector B.

$$C = \frac{Q}{Hb \times Wb \times Um} \quad \text{(Eq. 1)}$$

where

| | |
|---|---|
| Q | Modeled rate of VOC or PM10 emissions from soil ($\mu g$/sec). |
| Hb | Downwind height of box (m), estimated to be 2 m (breathing height). |
| Wb | Width of box, crosswind dimension of affected area, estimated to be 69m. |
| Um | Average wind speed through box (4.2 m/sec). |

The emission rates for vapor-phase and particle-bound constituents to the atmosphere are also used in the infinite line source model to calculate ambient air concentrations, $C_{voc}$ and $C_{part}$ ($\mu g/m^3$), in the current residential community located approximately 300 meters east of Site L.

$$C_{voc} \text{ or } C_{part} = \frac{2 \times Q}{2 \times \pi \times \sigma_z \times Um} \quad \text{(Eq. 2)}$$

where:

| | |
|---|---|
| q | Emissions per unit length of the line source (g/sec-m); calculated by dividing the total Q ($\mu g$/sec) by lenght of the creek bed (400 m). |
| $\pi$ | 3.14, unitless. |
| $\sigma_z$ | 11 m, based on Figure 2-3 from Turner (1970), for D stability class. |
| Um | Mean wind spead (m/sec). |

---

| | |
|---|---|
| $C_{voc}$ | Ambient air concentration for volatile organic compounds. |
| $C_{part}$ | Ambient air concentration for particulates. |
| g | Grams. |
| m | Meters. |
| $m^3$ | Cubic meter. |
| $\mu g$ | Micrograms. |
| sec | Second. |

Table 9. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Dead Creek Sector B and Site L, Sauget-Cahokia, Illinois.

| Constituent | Ca (ug/m3) | RfC (ug/m3) | Unit Risk (ug/m3) | HQ | ELCR |
|---|---|---|---|---|---|
| VOCs | | | | | |
| Acetone | 1.1E-06 | NA | - | NA | - |
| 2-Butanone | 8.5E-09 | 3.0E+02 | - | 2.8E-11 | - |
| Carbon disulfide | 2.8E-08 | 1.0E+01 | - | 2.8E-09 | - |
| Chlorobenzene | 1.8E-06 | 2.0E+01 | - | 9.0E-08 | - |
| Ethylbenzene | 3.0E-09 | 1.0E+03 | - | 3.0E-12 | - |
| Tetrachloroethene | 4.2E-10 | NA | 5.2E-07 | NA | 2.2E-16 |
| Toluene | 1.1E-06 | 2.0E+03 | - | 5.5E-10 | - |
| Xylenes | 6.3E-08 | 3.0E+02 | - | 2.1E-10 | - |
| Semi-VOCs | | | | | |
| bis(2-Ethylhexyl)phthalate | 5.8E-10 | NA | NA | NA | NA |
| Butylbenzylphthalate | 9.1E-12 | NA | NA | NA | NA |
| 4-Chloroaniline | 2.3E-10 | NA | - | NA | - |
| 2-Chlorophenol | 3.0E-11 | NA | - | NA | - |
| 1,2-Dichlorobenzene | 2.3E-07 | 2.0E+02 | - | 1.2E-09 | - |
| 1,3-Dichlorobenzene | 1.6E-07 | NA | - | NA | - |
| 1,4-Dichlorobenzene | 9.9E-07 | 7.0E+02 | NA | 1.4E-09 | NA |
| 2,4-Dichlorophenol | 5.7E-11 | NA | - | NA | - |
| 2,4-Dimethylphenol | 1.9E-12 | NA | - | NA | - |
| Diethylphthalate | 1.4E-12 | NA | - | NA | - |
| Hexachlorobenzene | 6.7E-12 | NA | 4.6E-04 | NA | 3.1E-15 |
| Isophorone | 3.7E-12 | NA | NA | NA | NA |
| 4-Methylphenol | 1.7E-12 | NA | NA | NA | NA |
| n-Nitrosodiphenylamine | 4.6E-11 | NA | NA | NA | NA |
| PAHs (carcinogenic) | 3.7E-09 | NA | 1.7E-03 | NA | 6.3E-12 |
| PAHs (total) | 6.1E-09 | NA | - | NA | - |
| PCBs | 1.0E-08 | NA | NA | NA | NA |
| Pentachlorophenol | 2.0E-10 | NA | NA | NA | NA |
| Phenol | 5.9E-11 | NA | - | NA | - |
| 1,2,4-Trichlorobenzene | 1.1E-08 | 9.0E+00 | - | 1.2E-09 | - |
| 2,4,5-Trichlorophenol | 5.9E-12 | NA | - | NA | - |
| 2,4,6-Trichlorophenol | 8.6E-11 | NA | 3.1E-06 | NA | 2.7E-16 |
| Inorganics | | | | | |
| Antimony | 2.9E-09 | NA | - | NA | - |
| Arsenic | 1.1E-08 | NA | 4.3E-03 | NA | 4.7E-11 |
| Barium | 6.2E-07 | 5.0E+01 | - | 1.2E-08 | - |
| Cadmium | 6.4E-09 | NA | 1.8E-03 | NA | 1.2E-11 |
| Calcium | 2.6E-07 | NA | - | NA | - |

Footnotes appear on page 2.

Table 9. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Dead Creek Sector B and Site L, Sauget-Cahokia, Illinois.

| Constituent | Ca (ug/m3) | RfC (ug/m3) | Unit Risk (ug/m3) | HQ | ELCR |
|---|---|---|---|---|---|
| Chromium | 1.6E-08 | 2.0E-03 | 1.2E-02 | 8.0E-06 | 1.9E-10 |
| Cobalt | 4.0E-10 | NA | - | NA | - |
| Copper | 1.7E-06 | NA | - | NA | - |
| Cyanide | 6.9E-10 | NA | - | NA | - |
| Iron | 4.0E-06 | NA | - | NA | - |
| Lead | 1.7E-07 | NA | NA | NA | NA |
| Magnesium | 5.5E-08 | NA | - | NA | - |
| Mercury | 3.1E-10 | 3.0E-01 | - | 1.0E-09 | - |
| Nickel | 1.1E-07 | NA | 2.4E-04 | NA | 2.6E-11 |
| Selenium | 6.0E-10 | NA | - | NA | - |
| Silver | 1.7E-09 | NA | - | NA | - |
| Zinc | 1.8E-06 | NA | - | NA | - |
| | | | **Total Risks** | **8E-06** | **3E-10** |

| | |
|---|---|
| - | Not a carcinogen. |
| Ca | Predicted average concentration in air. |
| ELCR | Excess lifetime cancer risk (Ca x Unit Risk). |
| HQ | Hazard quotient (Ca/RfC); the hazard index is the sum of the HQs. |
| NA | Not available. |
| PAHs | Polycyclic aromatic hydrocarbons. |
| PCBs | Polychlorinated biphenyls. |
| RfC | Reference concentration. |
| Semi-VOCs | Semivolatile organic compounds. |
| ug/m3 | Micrograms per cubic meter. |
| Unit Risk | Risk associated with breathing one ug/m3, 24-hours/day for 70 years. |
| VOCs | Volatile organic compounds. |

Table 10. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Southern Section of Dead Creek Sector B and Site M, Sauget-Cahokia, Illinois.

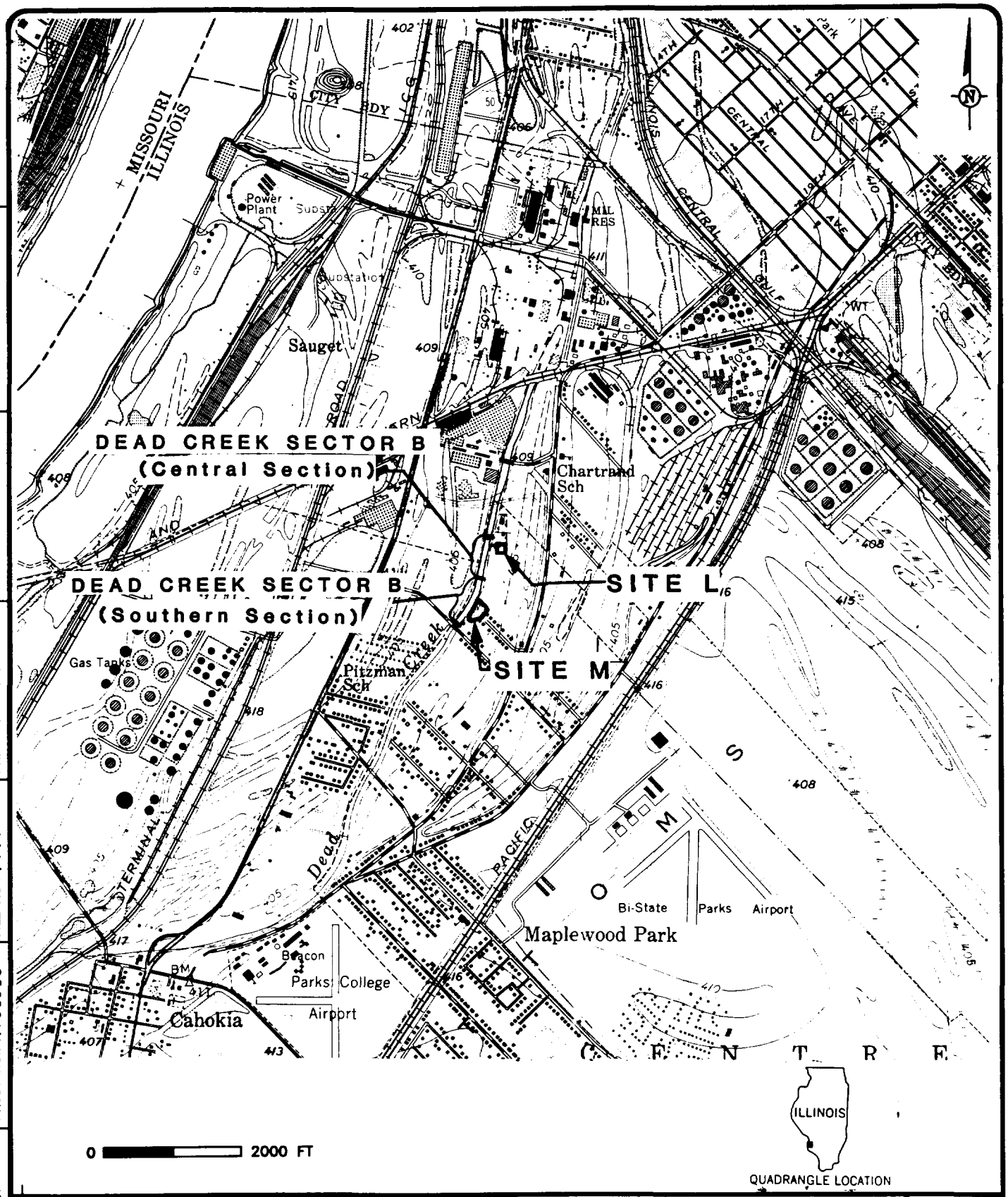
| Constituent | Ca (ug/m3) | RfC (ug/m3) | Unit Risk (ug/m3) | HQ | ELCR |
|---|---|---|---|---|---|
| VOCs | | | | | |
| Acetone | 4.9E-06 | NA | - | NA | - |
| 2-Butanone | 8.6E-07 | 3.0E+02 | - | 2.9E-09 | - |
| Carbon disulfide | 2.5E-07 | 1.0E+01 | - | 2.5E-08 | - |
| Chlorobenzene | 8.7E-05 | 2.0E+01 | - | 4.4E-06 | - |
| Ethylbenzene | 3.0E-07 | 1.0E+03 | - | 3.0E-10 | - |
| Tetrachloroethene | 4.2E-08 | NA | 5.2E-07 | NA | 2.2E-14 |
| Toluene | 3.4E-07 | 2.0E+03 | - | 1.7E-10 | - |
| Xylenes | 2.1E-07 | 3.0E+02 | - | 7.0E-10 | - |
| Semi-VOCs | | | | | |
| bis(2-Ethylhexyl)phthalate | 1.2E-09 | NA | NA | NA | NA |
| 2-Chlorophenol | 1.5E-10 | NA | - | NA | - |
| 1,2-Dichlorobenzene | 1.1E-05 | 2.0E+02 | - | 5.5E-08 | - |
| 1,3-Dichlorobenzene | 4.5E-06 | NA | - | NA | - |
| 1,4-Dichlorobenzene | 2.7E-05 | 7.0E+02 | NA | 3.9E-08 | NA |
| 2,4-Dichlorophenol | 3.5E-10 | NA | - | NA | - |
| 2,4-Dimethylphenol | 2.0E-10 | NA | - | NA | - |
| Isophorone | 3.8E-10 | NA | NA | NA | NA |
| 4-Methylphenol | 1.7E-10 | NA | NA | NA | NA |
| PAHs (carcinogenic) | 3.8E-08 | NA | 1.7E-03 | NA | 6.5E-11 |
| PAHs (total) | 8.1E-08 | NA | - | NA | - |
| PCBs | 1.1E-07 | NA | NA | NA | NA |
| Pentachlorophenol | 2.2E-09 | NA | NA | NA | NA |
| 1,2,4-Trichlorobenzene | 1.1E-08 | 9.0E+00 | - | 1.2E-09 | - |
| Inorganics | | | | | |
| Antimony | 6.3E-08 | NA | - | NA | - |
| Arsenic | 1.3E-07 | NA | 4.3E-03 | NA | 5.6E-10 |
| Barium | 1.2E-05 | 5.0E+01 | - | 2.4E-07 | - |
| Cadmium | 2.7E-07 | NA | 1.8E-03 | NA | 4.9E-10 |
| Calcium | 2.7E-05 | NA | - | NA | - |
| Chromium | 1.7E-07 | 2.0E-03 | 1.2E-02 | 8.5E-05 | 2.0E-09 |
| Cobalt | 4.1E-08 | NA | - | NA | - |
| Copper | 3.4E-05 | NA | - | NA | - |
| Cyanide | 1.7E-09 | NA | - | NA | - |
| Iron | 1.0E-04 | NA | - | NA | - |
| Lead | 2.9E-06 | NA | NA | NA | NA |
| Magnesium | 5.6E-06 | NA | - | NA | - |
| Mercury | 3.9E-09 | 3.0E-01 | - | 1.3E-08 | - |

Footnotes appear on page 2.

Table 10. Inhalation Risks and Calculations for Constituents of Concern, Nearest Residential Community, Southern Section of Dead Creek Sector B and Site M, Sauget-Cahokia, Illinois.

| Constituent | Ca (ug/m3) | RfC (ug/m3) | Unit Risk (ug/m3) | HQ | ELCR |
|---|---|---|---|---|---|
| Inorganics (continued) | | | | | |
| Nickel | 3.2E-06 | NA | 2.4E-04 | NA | 7.7E-10 |
| Selenium | 9.7E-09 | NA | - | NA | - |
| Silver | 5.2E-08 | NA | - | NA | - |
| Zinc | 5.0E-05 | NA | - | NA | - |
| | | | **Total Risks** | **9E-05** | **4E-09** |

| | |
|---|---|
| - | Not a carcinogen. |
| Ca | Predicted average concentration in air. |
| ELCR | Excess lifetime cancer risk (Ca x Unit Risk). |
| HQ | Hazard quotient (Ca/RfC); the hazard index is the sum of the HQs. |
| NA | Not available. |
| PAHs | Polycyclic aromatic hydrocarbons. |
| PCBs | Polychlorinated biphenyls. |
| RfC | Reference concentration. |
| Semi-VOCs | Semivolatile organic compounds. |
| ug/m3 | Micrograms per cubic meter. |
| Unit Risk | Risk associated with breathing one ug/m3, 24-hours/day for 70 years. |
| VOCs | Volatile organic compounds. |



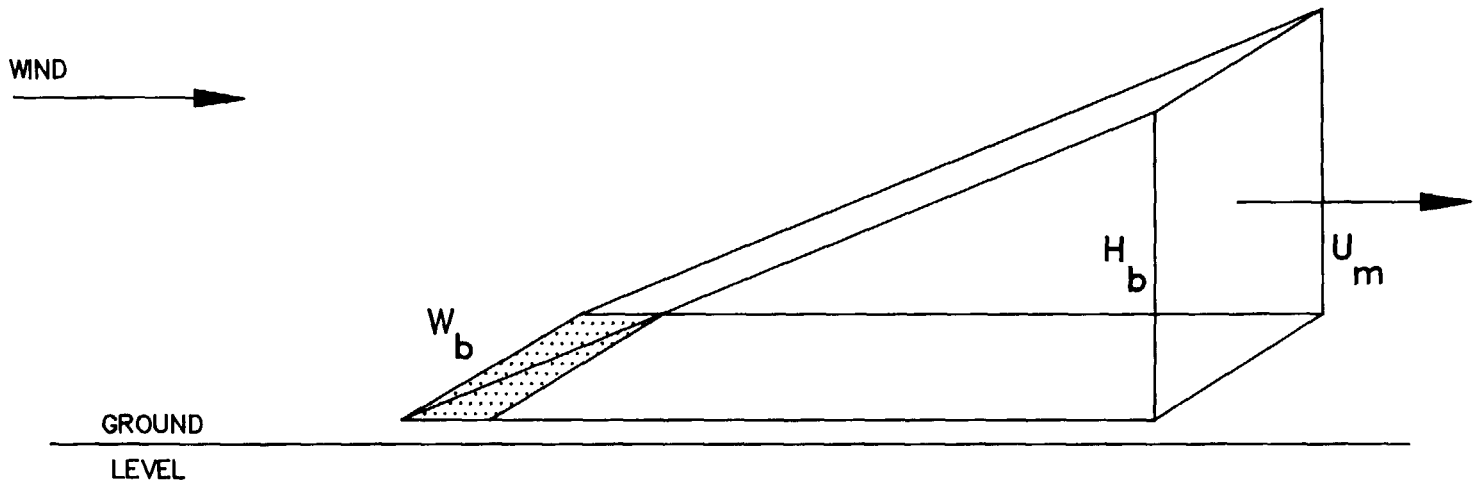

DRAFTER: V. CARUNCHO | APPROVED: B. BLUM | CHECKED: B. BLUM | DRAWING: TOPO | FILE NO.: 1444 | PROJECT NO.: NY60508 | DWG DATE: 8/91

GERAGHTY & MILLER, INC.
*Environmental Services*

LOCATION OF DEAD CREEK SECTOR B AND SITES L AND M, SAUGET–CAHOKIA, ILLINOIS

FIGURE **1**

| DWG DATE: 4/92 | PRJCT NO.: NY60509 | FILE NO.: | DRAWING: FIELDBOX | CHECKED: D. COLTON | APPROVED: D. COLTON | DRAFTER: V. CARUNCHO |
|---|---|---|---|---|---|---|




$$C_{voc} \text{ or } C_{part} = \frac{Q}{Hb \times Wb \times Um}$$

Where

| | |
|---|---|
| C voc | Ambient air concentration for volatile organic compounds. |
| C part | Ambient air concentration for particulates. |
| Q | Modeled rate of VOC or PM10 emissions from soil (ug/sec). |
| Hb | Downwind height of box is estimated to be 2 meters. |
| Wb | Width of box, crosswind dimension of affected area, estimated to be 225 meters. |
| Um | Average wind speed through box (4.2 meters/sec). |

GERAGHTY & MILLER, INC.
*Environmental Services*

DIAGRAM FOR THE NEAR-FIELD BOX MODEL, DEAD CREEK SECTOR B AND SITES L AND M, SAUGET-CAHOKIA, ILLINOIS

MONSANTO, SAUGET

FIGURE 2